

SPECIFICATION AMENDMENTS

On page 1, insert above line 1, insert--Priority Claim

The present application claims priority on European Patent Application 02254697.2 filed 20 June 2002.--

On page 1, above line 1, insert--Field of the Invention--

On page 1, above line 8, insert--Background of the Invention--

On page 2, after line 9, insert--Summary of the Invention

The present invention is directed to a reactor system suitable for carrying out chemical reactions, comprising one or more common reactant feed lines, two or more single unit operated reactor sections and one or more common product discharge lines.--

On page 2, above line 10, insert--Detailed Description of the Invention

Paragraph at line 10 of page 2, ending at line 19 of page 3, has been amended as follows:

■ --The present invention ~~tries to find~~ finds another way for the scale-up or the further scale-up of chemical reactors. Rather than ~~simply~~ increasing the size of an existing reactor (including adaptation of the reactor internals, catalyst beds, mixing internals, cooling system, feed lines/feed distribution, product withdrawal etc.), either in diameter and/or height, two or more reactors of a certain, preferably identical, size ~~are~~ may be combined and operated as one single unit. The common feed lines, i.e. gas and/or liquid reactor system feed lines, ~~are~~ may be divided into as many equivalent streams as there are reactors and introduced into the different equivalent reactors. Cooling and/or heating systems ~~are~~ may be shared between the reactors. There ~~will~~ may be one or more common product discharge lines. The reactors ~~are~~ may be operated as one single unit. The control of the reactant feed to the reactor system is may be carried out by means of managing the feed flow (amount, temperature, composition, pressure etc.) in the one or more common reactant feed lines, without ~~There is in the single unit operation no~~ individual control of each reactor sections. The control of the total product flow of the reactor system in the single unit operated ~~is done~~

~~may be accomplished~~ by managing the product flow in the one or more common product discharge lines. ~~rather than having~~ ~~In this type of operation there is no~~ individual control of the product discharge of each reactor section. Thus, ~~it is not possible to take~~ one or more reactors ~~may not be taken~~ out of operation ~~rather~~ - Only the complete reactor system ~~can~~ ~~may~~ be taken out of operation. ~~It is not possible to influence the~~ ~~The~~ conditions in one of the reactors ~~may not be influenced~~ ~~in a differently than those way as~~ in one of the other reactors. Turning ~~of~~ ~~off~~ one of the reactant feed lines ~~will result in the fact that~~ ~~results in~~ none of the reactors ~~receiving~~ ~~will receive~~ the reactant feed stream ~~any longer~~. Closing one of the product discharge lines ~~will results~~ ~~in the fact that~~ none of the reactors ~~will be able~~ ~~any more to discharge~~ ~~discharging~~ its products. Independent heating or cooling of the ~~The~~ reactor sections is ~~may not be independently heated or cooled~~. ~~not possible~~. Reactor control ~~will~~ ~~may~~ be based on information obtained from all reactors present. A runaway in one of the reactors ~~cannot be solved by closing down the reactor involved~~. It has to ~~may~~ result in the shut down of the complete system. Feed stream control is ~~may be~~ carried out by control of the common feed gas/liquid reactant feed lines.--

On page 3, delete line 20-24.

Paragraph at line 25 of page 3, ending at line 26 of page 4, has been amended as follows:

--~~A main advantages of the~~ ~~The~~ present reactor system ~~is the fact that~~ ~~scaling-up becomes~~ ~~allows~~ easier ~~scale-up~~. For instance, when a reactor of a certain size has proven to perform its tasks well, there is no need for a further scale-up of the ~~individual~~ reactor. Combining a multitude of similar reactors and operating ~~it~~ ~~them~~ as ~~one~~ a single unit with common reactant feed lines and common product discharge lines will result in the desired scale-up ~~of a process~~. Or, in the case that a certain (large) scale-up for a specific reactor is required, the scale-up ~~can~~ ~~may~~ be limited by using e.g. three or four reactor sections operated as a single unit. The ~~required~~ scale-up ~~is then~~ ~~in than~~ reduced by a factor three or four. ~~Further advantages are the~~ ~~The~~ lower weight of the reactor ~~makes issues such as making transport, handling and lifting easier~~. It ~~will be appreciated that the~~ ~~The~~ size of a reactor may be restricted by workshop limitations, road limitations, bridge limitations, lifting equipment limitations etc. ~~The smaller size of the reactor may result in the fact that more companies are able to produce the reactor. Also simultaneous production by one or more vendors will be possible~~. As the reactor system is single unit operated, ~~there is no~~

additional workforce may be needed to operate the unit from ~~the a~~ control room. From a process control point of view, there is no difference between one large reactor and the reactor system of the present invention: the reactor system of the present invention is may be operated in the same way as one single large reactor. In general, the heat-up/cool-down rates for the reactor system according to the present invention ~~will~~ may be faster than for one large single reactor. Some additional maintenance may be required, while also a somewhat larger plot space may be required. ~~However, these small disadvantages are clearly set off by the advantages. In addition~~ However, maintenance within the reactor may be done more quickly ~~quicker~~, as work ~~will~~ may be divided over several places.--

Paragraph at line 27 of page 4, ending at line 6 of page 5, has been amended as follows:

-- The above described reactor system is may be especially useful for strongly exothermic reactions. An example of such a reaction is the conversion of synthesis gas, a mixture of carbon monoxide and hydrogen, into methanol or hydrocarbons. As these conversions are highly exothermic, ~~it will be appreciated that~~ extensive cooling is necessary. This results in ~~an a~~ relatively high amount of cooling internals inside the reactor, resulting in a reactor which reaches relatively quickly reaches its natural limits in scaling-up. Another example is the oxidation of (lower) olefins, ~~e.g. for example~~ the catalytical conversion of ethylene into ethylene-oxide in a multitubular fixed bed reactor. The reactor system is also suitable for biochemical reactions. --

Paragraph at line 7 of page 5 has been amended as follows:

-- The reactor system according to the present invention suitably comprises between two and twenty single units operated reactor sections, preferably between three and eight single unit operated reactor sections, and more preferably comprises four such sections. Usually a reactor section will comprise a more or less conventional reactor, i.e. an elongated cylindrical reactor, which, when in use, ~~will~~ may be a vertical reactor. Suitable reactor sections ~~are the well known~~ may be chemical reactors such as tank reactors, (multi) tubular reactors, tower reactors, ~~fluidised~~ fluidized bed reactors and slurry phase reactors. See, for instance, Perry's Chemical Engineers' Handbook (McGraw-Hill Book Company, 6th edition, 4-24-4-27) and Chemical Reactor Design and Operation (Westerterp, Van Swaaij an Beenackers, John Wiley & Sons, 1984). It is also possible ~~that~~ to locate the reactor sections ~~are located~~ in one large reactor. ~~This will overcome a number of the~~

~~problems related to scaling-up, however, some advantages as described above may disappear.~~ Preferably, all reactor sections have the same size. However, this is not essential, and different sizes of reactors may be used. It will be appreciated that in that case, ~~measures have to be taken that~~ the feed should be is distributed in the desired ratio over the reactors. Also, cooling/heating systems may need adaptation. The single unit operated reactor sections ~~will~~ may be operated in parallel. The reactor system does not comprise reactor sections which are operated in series. Preferably each reactor section is a separated, individual chemical reactor, suitably comprising a shell (or vessel) and one or more reaction zones.--

Paragraph at line 4 of page 6 has been amended as follows:

-- In most cases each reactor section will comprises one or more catalyst beds. Also slurry reactors may be used. In view of the large heat generation in hydrocarbon synthesis from syngas, slurry reactors may have advantages over fixed bed reactors in terms of heat transfer. On the other hand major technical issues associated with slurry reactors include hydrodynamics and solids management. In a preferred embodiment the reactor sections comprise a multitubular fixed bed catalyst arrangement. The tubes are filled with catalyst particles, the tubes are surrounded by cooling medium, especially a mixture of water and steam. Thus, the reactor sections each comprise an indirect heat exchange system, which heat exchange systems are jointly operated. Preferably the well known thermosiphon system is to be used.--

Paragraph at line 20 of page 6, ending at line 4 of page 7, has been amended as follows:

-- Depending on the chemical reaction to be carried out, gaseous and/or liquid feeds ~~are to~~ may be introduced in the reactor. All possible reactor flow regimes may be used, i.e. up-flow and/or downflow, cocurrent and/or countercurrent. Also gas and/or liquid recycles may be used. In the case of the synthesis of hydrocarbons, one common gas reactant feed line will may be used to introduce the syngas into the reactor system. This feed is may be split up in as many streams as are necessary for the number of attached reactor sections, and fed to the different reactor sections. In the case that both a gas and a liquid have to be introduced in the reactor sections, there is preferably a separated gas feed line and a separated liquid feed line. It is recommended that reactors of the same type are used in the system according to the invention, preferably of the same size. In the case of

heterogeneous catalytic reactions preferably the same catalyst is used in all reactor sections, although this is not essential. --

Paragraph at line 17 of page 7, ending at line 2 of page 8, has been amended as follows:

--Suitably, the reactor sections in the reactor system of the present invention are identical. Size, catalyst, design, cooling capacity etc. are preferably similar. ~~This is~~ In this case, the ~~preferred option as reactor manufacture in that case~~ is a simple duplication process. However, identical reactor sections are not essential. Different sizes may be used, as well as different types of catalyst ~~may be used. It will be appreciated that measures have to be taken that a~~ In that case, correct feed distribution over the reactors has to be made, depending on the differences in design, catalyst etc. Also, the cooling capacity may be different from one reactor to another, resulting in different conditions in the reactor sections of one reactor system. It should be taken into account, that once different conditions are created in one or more reactor section of the system according to the invention, ~~there are no possibilities to change the conditions in one or more of the reactors~~ may not be independently changed, as the system is operated as one single unit.--

Paragraph at line 3 of page 8 has been amended as follows:

-- The hydrocarbon synthesis as mentioned above may be any suitable hydrocarbon synthesis step known to ~~the man~~ one skilled in the art, but is preferably a Fischer Tropsch reaction. The synthesis gas to be used for the hydrocarbon synthesis reaction, especially the Fischer Tropsch reaction, is may be made from a hydrocarbonaceous feed, especially by partial oxidation, catalytic partial oxidation and/or steam/methane reforming. In a suitable embodiment, an autothermal reformer is used ~~or a process in which~~ wherein the hydrocarbonaceous feed is introduced into a reforming zone, followed by partial oxidation of the product thus obtained, which partial oxidation product is used for heating the reforming zone. The hydrocarbonaceous feed is suitably methane, natural gas, associated gas or a mixture of C₁₋₄ hydrocarbons, especially natural gas.--

Paragraph at line 19 of page 8 has been amended as follows:

-- To adjust the H₂/CO ratio in the syngas, carbon dioxide and/or steam may be introduced into the partial oxidation process and/or reforming process. The H₂/CO ratio of

the syngas is suitably between 1.3 and 2.3, preferably between 1.6 and 2.1. If desired, (small) additional amounts of hydrogen may be made by steam methane reforming, preferably in combination with the water shift reaction. The additional hydrogen may also be used in other processes, e.g. hydrocracking.--

Paragraph at line 28 of page 8, ending at line 4 of page 9, has been amended as follows:

-- The synthesis gas obtained ~~in the way~~ as described above, usually having a temperature between 900 °C and 1400 °C, is cooled to a temperature between 100 °C and 500 °C, suitably between 150 °C and 450 °C, preferably between 300 °C and 400 °C, preferably under the simultaneous generation of power, e.g. for example in the form of steam. Further cooling to temperatures between 40 °C and 130 °C, preferably between 50 °C and 100 °C, is may be done in a conventional heat exchanger, especially a tubular heat exchanger.--

Paragraph at line 5 of page 9 has been amended as follows:

-- The purified gaseous mixture, comprising predominantly hydrogen and carbon monoxide, is may be contacted with a suitable catalyst in the catalytic conversion stage, in which the normally liquid hydrocarbons are formed.--

Paragraph at line 31 of page 9, ending at line 17 of page 10, has been amended as follows:

-- If desired, the catalyst may also comprise one or more metals or metal oxides as promoters. Suitable metal oxide promoters may be selected from Groups IIA, IIIB, IVB, VB and VIB of the Periodic Table of Elements, or the actinides and lanthanides. In particular, oxides of magnesium, calcium, strontium, barium, scandium, yttrium, lanthanum, cerium, titanium, zirconium, hafnium, thorium, uranium, vanadium, chromium and manganese are very suitable promoters. Particularly preferred metal oxide promoters for the catalyst ~~used to prepare the waxes for use~~ in the present invention are manganese and zirconium oxide. Suitable metal promoters may be selected from Groups VIIB or VIII of the Periodic Table. Rhenium and Group VIII noble metals are particularly suitable, with platinum and palladium being especially preferred. The amount of promoter present in the catalyst is suitably in the range of from 0.01 to 100 pbw, preferably 0.1 to 40, more preferably 1 to 20 pbw, per 100 pbw of carrier. The most preferred promoters are selected from vanadium, manganese, rhenium, zirconium and platinum.--

Paragraph at line 1 of page 11 has been amended as follows:

-- The catalytic conversion process may be performed under conventional synthesis conditions known in the art. Typically, the catalytic conversion may be effected performed at a temperature in the range of from 150 °C to 300 °C, preferably from 180 °C to 260 °C. Typical total pressures for the catalytic conversion process are in the range of from 1 to 200 bar absolute, more preferably from 10 to 70 bar absolute. In the catalytic conversion process, preferably especially more than 75 wt% of C₅⁺, more preferably more than 85 wt% C₅⁺ hydrocarbons are formed. Depending on the catalyst and the conversion conditions, the amount of heavy wax (C₂₀⁺) may be up to 60 wt%, sometimes up to 70 wt%, and sometimes even up ~~to~~ to 85 wt%. Preferably a cobalt catalyst is used, a low H₂/CO ratio is used and a low temperature is used (190–230 °C). To avoid any coke formation, it is preferred to use an H₂/CO ratio of at least 0.3. It is especially preferred to carry out the Fischer Tropsch reaction under such conditions that the SF-alpha value, for the obtained products having at least 20 carbon atoms, is at least 0.925, preferably at least 0.935, more preferably at least 0.945, even more preferably at least 0.955.--

Paragraph at line 23 of page 11 has been amended as follows:

-- Preferably, a Fischer-Tropsch catalyst is used, which yields substantial quantities of paraffins, more preferably substantially unbranched paraffins. A most suitable catalyst for this purpose is a cobalt-containing Fischer-Tropsch catalyst. Such catalysts are described in the literature, see e.g. AU 698392 and WO 99/34917.--

On page 13, above line 1, insert --We claim:--